

The distribution, relative abundance and conservation status of *Doryanthes palmeri* (Doryanthaceae) in New South Wales

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Doryanthes palmeri is a giant, flowering succulent herb endemic to north-east NSW and south-east Queensland. Prior to this study, only two *D. palmeri* sites had been reported in NSW. This study revealed a further nine sites, all of which are restricted to the Mt Warning caldera.

Doryanthes palmeri occurs on infertile lithosols or grows as a lithophyte on bare rock. It occurs in a narrow band of vegetation along the cliff-tops and on steep cliff-faces or rocky ledges in montane heath next to subtropical rainforest, wet sclerophyll forest or warm temperate forest. There are around 6000 mature *D. palmeri* plants in north-east NSW. Populations at each site occur as clusters on a relatively small amount of the available habitat. The area of occupancy of *D. palmeri* is less than 1 km² with an average distance between sites of 6.3 km. However, the distribution consists of four groups of populations with an average of 15 km between the groups suggesting a poor ability to disperse.

There appear to be limits to the extent that plants can expand at some sites which are due mainly to low recruitment of juveniles into the population, illegal seed harvesting and the competition of faster growing native or weed species. The present populations, therefore, are restricted to their current exposed positions. The small restricted, fragmented distribution and current threats to the population suggests that *D. palmeri* should be regarded as a vulnerable species.

Introduction

Doryanthaceae is an Australian endemic family with one genus *Doryanthes* and two species *D. palmeri* W. Hill ex Benth. and *D. excelsa* Corrêa. *Doryanthes excelsa* (Gymea Lily) grows in the Sydney area of New South Wales (NSW). The distribution, life history and ecology of this species have previously been investigated (e.g. Newman 1928, 1929; Patil and Pai 1981; Nash 1996). In contrast, *Doryanthes palmeri*, the focus of this paper, is less well known. The only publication on *D. palmeri* was a description of its horticultural merits with a brief mention of its distribution in south-east Queensland (Forster 1995).

Doryanthes palmeri (the Giant Spear Lily) is a giant rosette fleshy to more or less succulent herb with leaves up to 4 m long and 22 cm wide. The flower scape varies in length between 4–8 m with a thyrse type inflorescence up to 1.7 m long containing up to 350 flowers. The flowers are a scarlet red to red-orange colour measuring from 5–5.5 cm long, 4–5 cm in diameter with pedicels 5–12 cm long (Perry 1998).

Doryanthes palmeri is a long-lived plant. The oldest recorded live specimen is 54 years old and is growing in the Australian House at Kew Gardens, London. Under these conditions it was nearly 20 years old before the plant first flowered (M. Stanniforth pers. comm.¹). A cultivated specimen in north-eastern NSW, however, took 13 years to flower (R. Maslan pers. comm.²). It is only after flowering that *D. palmeri* is able to produce new rosettes from leaf nodes at the base of the plant (M. Stanniforth pers. comm.).

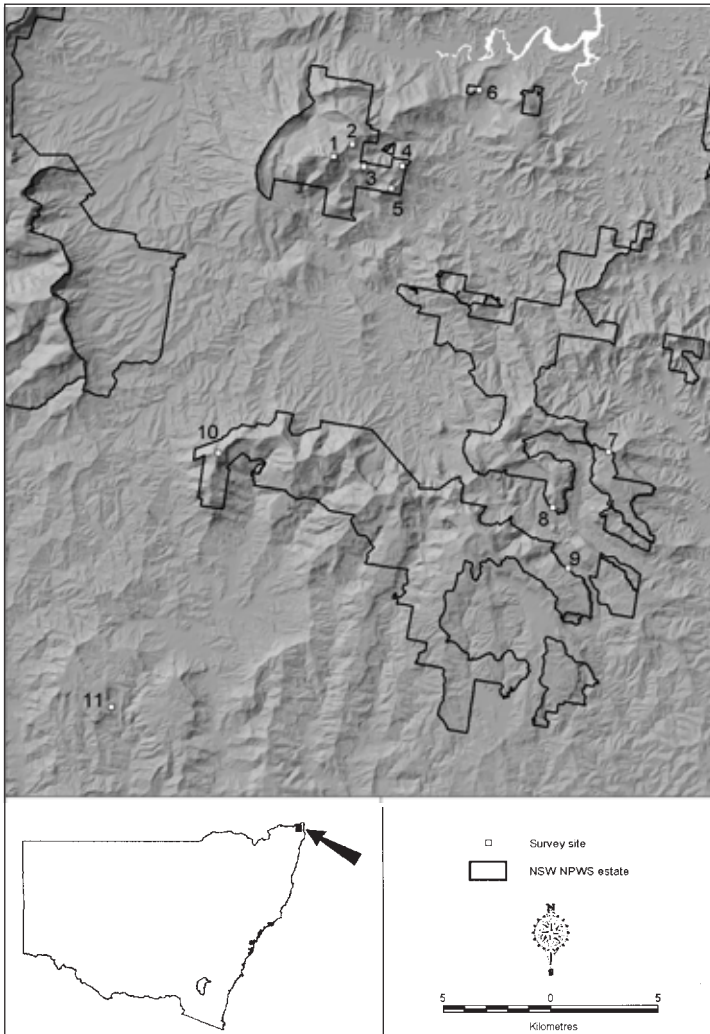


Fig. 1. Distribution map of *Doryanthes palmeri* in New South Wales. Key to localities: 1, Mt Warning; 2, Unnamed mountain; 3, Mt Booyong; 4, Mt Uki; 5, The Sisters; 6, Hattons Bluff; 7, Mt Boogaram; 8, Blackbutt Plateau; 9, Wanganui Gorge; 10, Mt Burrel; 11, Mt Billen.

The distribution and abundance are important for determining the appropriate conservation status and management of a species (e.g. Gilfedder and Kirkpatrick 1998, Lynch 1999). With only two recorded populations *D. palmeri* appears to be a rare plant in NSW, yet it is not included under the NSW *Threatened Species Conservation (TSC) Act 1995*. The aim of this study is to investigate the degree of rarity, relative abundance and habitat of *D. palmeri* in north-east NSW.

The distribution of *D. palmeri* is restricted to south-east Queensland and north-east NSW (Harden 1993). In south-east Queensland, it has a disjunct distribution from Mt Beau Brummel to Mt Superbus in the Main Range area and from Springbrook Plateau to Upper Tallebudgera including The Cougals (Forster 1995; Queensland Herbarium; National Herbarium of NSW). In north-east NSW it is known from only two sites: Mt Warning (National Herbarium of NSW; Floyd 1985) and Mt Burrell (Floyd 1990) (Figure 1). Moreover, despite intensive vegetation surveys carried out by the NSW National Parks and Wildlife Service no new sites were reported in north-east NSW (NRAC 1995).

Methods

Study Area

The study area was the mountain ranges of the Mt Warning caldera (29°S, 153°E) in north-east NSW (Figure 1). The climate is subtropical, with an annual average rainfall between 1800 and 2400 mm that is biased to summer–autumn months (Bureau of Meteorology 2001). However, records at a higher elevation from Rummery Park in Whian Whian State Forest show an annual average rainfall of up to 3000 mm (Forestry Commission of NSW 1984). Weathering and erosion of the Tertiary basaltic and rhyolitic lava flows from the Tweed Shield Volcano centred on Mt Warning has led to the formation of many cliff-lines (Ewart et al. 1987).

The vegetation of the study area is mainly wet and dry sclerophyll forests and subtropical rainforest. Since logging in the region for red cedar in the 1840s, the region has had a long history of cattle grazing, dairy farming and timber plantations (Forestry Commission of NSW 1984). In recent years, national parks and nature reserves, including Mt Warning, Nightcap, Mt Jerusalem and Border Ranges NPs and Hattons Bluff NR have been established in the region. Some of these reserves are included in the Central Eastern Rainforest Reserves (Australia) World Heritage Area.

Distribution

Clarification of the positions that *D. palmeri* occupies in the landscape and information on site characteristics was obtained by surveying four of the known populations. These were Mt Cordeaux and Springbrook Plateau in south-east Queensland and Mt Warning and Mt Burrell in north-east NSW. These were used to predict the potential occurrence of *D. palmeri* in other north-eastern NSW areas. In particular, sites with exposed cliff-tops or rock outcrops along the rim of the eroded caldera wall were targeted. Geological, topographical and soil landscape maps were used to identify other potential sites. These maps were also used for cross-referencing with rock and soil samples collected from some *D. palmeri* sites. Potential sites were also gathered from field botanists, and rock-climbing and hang gliding enthusiasts who frequent mountainous areas.

Potential new sites were visited where possible. Some populations were inaccessible due to the steepness of the sites combined with the lack of tracks and the density of the vegetation, making it difficult to find a route in to the sites. However, the distinctive shapes of mature *D. palmeri* plants (i.e. relatively large) can be seen on the cliff-lines and rock ledges through 10 x 50 binoculars from vantage points at least several kilometres away. This technique was useful for identifying *D. palmeri* sites and providing a reasonable estimate of the number of individuals in each population that could not be visited. Populations were estimated to the nearest 10 100 or 1000.

Descriptions of the habitat and a vascular plant species list were gathered from each accessible site. Records were made of the positions that *D. palmeri* occupied in the landscape e.g. cliff-tops or rocky ledges. A general plant species list at each site was obtained by traversing the area around the *D. palmeri* plants and the surrounding forests. Floristic scores were rated as (4) very common, (3) common, (2) occasional, (1) rare or (0) not present. The species nomenclature follows Harden (1991–1993, 2000).

Table 1. Summary of *Doryanthes palmeri* sites in north-east NSW.

(NP) National Park; (NR) Nature Reserve; (*) new sites

Site (Land Tenure)	Lat. long.	Elevation (m)	Topo- graphy	Aspect	Sub- strate	Pop. size	Area (ha)
Mt Warning (Mt Warning NP)	28°24'S 153°16'E	700–980	cliff-face/ rocky ledges	N-NE	syenite	<2000	7.50
Mt Burrell to Sphinx Rock* (Nightcap NP)	28°31'S 153°12'E 28°31'S 153°13'E	550–900	cliff-top/ cliff-face	N–NW/ SW	basalt	<1000	45.00
Blackbutt Plateau* (Mt Jerusalem NP)	28°32'S 153°22'E	400–520	rocky ledges	W–SW	rhyolite	<300	3.10
Mt Boogeram* (Mt Jerusalem NP)	28°31'S 153°24'E	500–600	cliff-top/ cliff-face	N–NW	rhyolite	<100	0.10
Wanganui Gorge* (Nightcap NP)	28°34'S 153°23'E	360–380	cliff-top/ cliff-face	NW	rhyolite	<100	2.00
Mt Billen* (Private land)	28°37'S 153°09'E	300–365	cliff-face/ rocky ledges	NE	rhyolite	<500	7.30
Mt Uki* (Mt Warning NP)	28°24'S 153°18'E	560–600	rocky ledge	SE	granite	<100s	0.23
The Sisters* (Mt Warning NP)	28°24'S 153°17'E	500–560	rocky ledges	NE	granite	<100	0.45
Unnamed mtn* (Mt Warning NP)	28°23'S 153°16'E	600–620	rocky ledges	SE	gabbro	<40	0.16
Mt Booyong* (Mt Warning NP)	28°24'S 153°17'E	590–600	rocky ledges	SE	gabbro	<40	0.09
Hattons Bluff* (Hattons Bluff NR)	28°22'S 153°20'E	200–290	cliff-top/ rocky ledges	NE–SE	granite	<1500	2.00
Total						5780	65.93

To estimate the area of occupancy the horizontal and vertical area of each population was measured using topographical maps. These measurements were unobtainable in the field due to the steepness and inaccessibility of some or all of the total population at each site. Although this method is not precise, I attempted to be conservative with the estimate. The survey was carried out between October 1997 and January 2001.

Results

Distribution

Doryanthes palmeri was located at nine new sites within the Mt Warning caldera in north-east NSW. The two historic sites and eight of the nine new sites are in national parks or nature reserves (Fig. 1 and Table 1). There was one new site each on private land and a nature reserve. The geographic range of these sites is approximately 25 x 30 km with an average distance between sites of 6.3 km. The distribution contains four clusters of populations with an average of 15 km between the clusters (Fig. 1).

The four previously known sites (two each in south-east Queensland and north-east NSW) and three of the new sites: Blackbutt Plateau, Mt Boogeram and Wanganui Gorge, were visited and surveyed in detail. The remaining six sites could not be accessed and were surveyed through binoculars.

All the *D. palmeri* sites occurred on exposed cliff-tops, cliff-faces or rock ledges. Some *D. palmeri* plants, however, grow on rock ledges in gaps next to rainforest overstorey species. These plants were on the perimeter of the main populations on the south-western side of Mt Burrell, the north-eastern side of Mt Warning and the whole population which was on the south-western side of Blackbutt Plateau.

The substrates were mainly granite and rhyolite with two sites on gabbro and one each on basalt and syenite. Slopes were estimated to be between 60% and 90% with aspects generally ranging from north-west to south-east (Table 1). The elevations of the *D. palmeri* populations ranged from 200–980 m ASL.

Surveys of other apparently similar sites in the area were searched but *D. palmeri* was not located. The areas included were Minyon Falls, Nimbin Rocks, Tunttable Falls, Peates Mountain, Boogeram Falls, Nullum, Byrill Ridge, the Tweed, Mackellar and McPherson Ranges (Fig. 1).



Young *Doryanthes palmeri* growing in rock crevice in northern NSW.

Doryanthes palmeri was not located in the Border Ranges area situated between Mt Warning and the Main Range in south-east Queensland, nor was it found on any cliff-lines between the known sites.

Abundance

There was an estimated total population of less than 6000 mature *D. palmeri* plants found at 11 sites in north-east NSW (Table 1). The area of occupancy was estimated to be less than 1 km². Population sizes at each site ranged from 40 to 2000. It was estimated that eight sites had less than 500 mature plants each. The largest populations were at Hattons Bluff, Mt Warning and from Mt Burrell to Sphinx Rock. Each of these sites contained from 1000 to 1500 mature *D. palmeri* plants. The smallest populations were on Mt Booyong and the unnamed mountain in Mt Warning NP, each of which contained about 40 mature *D. palmeri* plants (Fig. 1 and Table 1). There was a lack of flowering by *D. palmeri* plants at several of the sites. This was mainly at the cooler south-east to south-westerly sites where *D. palmeri* was growing on rock ledges next to subtropical rainforest.

There appeared to be very few, if any, seedlings or juvenile *D. palmeri* plants at Wanganui Gorge and Blackbutt Plateau. At Wanganui Gorge, several juvenile *D. palmeri* plants on the cliff-top appeared to have been heavily grazed and flattened by herbivores. Some of these plants appear to have died as a result. In positions where mature plants were in reach of the herbivores, the younger central leaves were also grazed. Scats found around these plants appeared to be from wallabies. Wallaby scats were also found at Mt Warning, but no evidence of herbivory of *D. palmeri* plants was observed.

Table 2. The most common plant species and the number of sites that they occur with *Doryanthes palmeri* from seven surveyed sites in north-east NSW and south-east Queensland. (*) weed species.

Species	Family	Common Name	Number of Sites
<i>Dendrobium kingianum</i>	Orchidaceae	Pink Rock Orchid	7
<i>Lophostemon confertus</i>	Myrtaceae	Brush Box	7
<i>Pittosporum undulatum</i>	Pittosporaceae	Sweet Pittosporum	7
<i>Trochocarpa laurina</i>	Epacridaceae	Tree Heath	6
<i>Ageratina riparia</i> *	Asteraceae	Mist Weed	5
<i>Allocasuarina torulosa</i>	Casuarinaceae	Forest Oak	5
<i>Leucopogon lanceolatus</i>	Epacridaceae	Lance Bearded Heath	5
<i>Dianella caerulea</i>	Phormiaceae	Blue Flax Lily	5
<i>Xanthorrhoea latifolia</i> subsp. <i>maxima</i>	Xanthorrhoeaceae	Flat-leaved Grass Tree	5
<i>Plectranthus graveolens</i>	Lamiaceae	Sticky Cockspur Flower	4
<i>Eustrephus latifolius</i>	Luzuriagaceae	Wombat Berry	4
<i>Callistemon montanus</i>	Myrtaceae	Mountain Bottlebrush	4
<i>Leptospermum polygalifolium</i>	Myrtaceae	Yellow Tea-tree	4
<i>Lomandra spicata</i>	Phormiaceae	Mountain Matt-rush	4
<i>Rubus hillii</i>	Rosaceae	Queensland Bramble	4
<i>Ageratina adenophora</i> *	Asteraceae	Crofton Weed	3
<i>Hibbertia scandens</i>	Dilleniaceae	Climbing Guinea Flower	3
<i>Acacia melanoxylon</i>	Fabaceae	Blackwood	3
<i>Hardenbergia violacea</i>	Fabaceae	False Sarsaparilla	3
<i>Eucalyptus acmenoides</i>	Myrtaceae	White Mahogany	3
<i>Leptospermum variabile</i>	Myrtaceae	Tea Tree	3
<i>Peperomia tetraphylla</i>	Peperomiaceae	Four-leaved Pepper Plant	3
<i>Lomandra longifolia</i>	Phormiaceae	Spiny-headed Mat-rush	3
<i>Lantana camara</i> *	Verbenaceae	Common Lantana	3

Habitat

The *D. palmeri* populations were found in montane heath on infertile lithosols. A total of 23 plant species from 15 families were commonly found with *D. palmeri* (Table 2). The overstorey species in the heath include *Lophostemon confertus*, *Allocasuarina* species, *Acacia melanoxylon* and *Trochocarpa laurina*. The understorey is dominated by species of *Leucopogon*, *Leptospermum*, *Acacia*, *Xanthorrhoea* and *Rubus*. Ground cover species usually include *Lomandra* species, *Dianella caerulea* and *Plectranthus* species. Only one species, *Dendrobium kingianum*, occurred at all *D. palmeri* sites.

The heathland is next to wet sclerophyll forest, subtropical rainforest or warm temperate forest; the former two types are on deeper, more fertile soils than the latter type. In the wet sclerophyll forest the dominant tree species were generally *Lophostemon confertus*, *Eucalyptus* species, *Corymbia* species, *Pittosporum undulatum*, *Allocasuarina torulosa*, *Acacia melanoxylon*, *Acmena smithii* and *Archontophoenix cunninghamiana*. The understorey species include *Xanthorrhoea* species, *Lomandra* species, *Smilax australis*, terrestrial orchid species and grass species. In the subtropical rainforest the dominant overstorey species include *Heritiera trifoliolata*, *A. cunninghamiana*, *Ficus* species and *Dendrocnide* species. The understorey is composed of *P. undulatum*, *A. smithii*, *Cordyline* species, *Cyathea* species, *Alpinia* species, *Hibbertia scandens* and numerous terrestrial ferns. The warm temperate forest is dominated by *Ceratopetalum apetalum* with *Eucalyptus campanulata*, *L. confertus*, *P. undulatum*, *Acacia orites*, *Cuttsia viburnea*, *Cyathea leichhardtiana*, *Hibbertia dentata* and numerous terrestrial ferns and orchids in the understorey. The epiphytic species *Asplenium australasicum*, *Peperomia tetraphylla*, *Pyrrosia rupestris* and *Dendrobium kingianum* were sometimes found on rock ledges with *Doryanthes palmeri*.

Fire records for the National Parks that contained *D. palmeri* showed that 76 wildfires occurred between 1967 and 1997. Of these fires, one reportedly occurred on the western side of Mt Warning in 1992/93. A large fire burnt from Mt Matheson to Mt Nardi and another at Sphinx Rock in Nightcap NP in 1992/93 (M. O'Connell pers. comm.³). It is not known, however, whether any *D. palmeri* populations were affected by these fires. One fire in September 1985 swept up through the *D. palmeri* population on the north-western side and to the top of Mt Cordeaux in south-east Queensland (L. Shelly pers. comm.⁴). No pre-fire surveys of this site were reported in the literature, therefore, the effects of the fire on the *D. palmeri* plants is unknown. It can be assumed, however, that the presence of hundreds of mature individuals at the site during surveys in 1997 by the author means that, under the conditions at this site, they are able to survive occasional fires.

Weeds

A number of introduced weed species were found at sites with *Doryanthes palmeri* (Table 2). There were dense ground coverings of *Ageratina adenophora*, *A. riparia* and *Lantana camara* at Blackbutt Plateau and Mt Burrell. At both these sites, *L. camara* was climbing over the top of *Doryanthes palmeri* and was smothering the plants. At Blackbutt Plateau *D. palmeri* only grows on rock ledges in rainforest. Layers of *L. camara* were pushing these *D. palmeri* off the ledges in some places and shading them out in others. At this site small seedlings of the introduced tree *Cinnamomum camphora* were also present. At Wanganui Gorge *Ageratina riparia* and *Lantana camara* were commonly growing in crevices with *Doryanthes palmeri*.

Discussion

The total estimate of individual mature *Doryanthes palmeri* plants in NSW is less than 6000. This species is found at only 11 sites in a patchy, disjunct distribution from Hattons Bluff to Mt Billen in north-east NSW. Only two of these sites had previously been recorded. The distribution of *D. palmeri* was probably once more widespread across the volcanic landscape around Mt Warning but is now restricted to a few cliff-lines mainly along the Mt Warning caldera. Many similar habitats are available within the region but are not occupied by *D. palmeri*. Most of the *D. palmeri* populations occur on granitic or rhyolitic rock ledges, cliff-tops or cliff-faces at fairly high elevations. The steepness and the lack of tracks to some potential *D. palmeri* sites meant that some small or inaccessible populations may have been overlooked during the surveys. Therefore, data on the total extent and total number of mature individuals may be an under-estimate. However, as stated previously, *D. palmeri* is not on a large percentage of the available cliff-lines in the region. Indeed, most *D. palmeri* populations exist as localised clusters of between 40–100 plants on a very small percentage of the total cliff-lines available at each site suggesting a poor dispersal ability.

The habitat of *Doryanthes palmeri* where it occurs on cliff-tops is montane heath next to subtropical rainforest, warm temperate rainforest or wet sclerophyll forest. The largest populations are on exposed cliff-face sites, however, at some sites several plants or whole populations (e.g. Blackbutt Plateau) were growing in gaps on rock ledges in subtropical rainforest. *Doryanthes palmeri* plants in these shadier situations rarely had flowers during this study. Under low light conditions *D. palmeri* appears to direct its energy into vegetative growth and less to sexual reproduction. This is evident from the large green, mostly single plants at these sites and their proportional lack of flower scapes and very few, if any, juveniles. In contrast, *D. palmeri* plants on the exposed, north/north-west facing cliff-faces from Mt Burrell to Sphinx Rock are mostly in small, chlorotic clumps; yet they produce more flower scapes and more juveniles within the population.

Clumping of *Doryanthes palmeri* plants (i.e. rosettes or ramets formed at the base of a plant) occurs only after a plant has flowered and withered (M. Stanniforth pers. obs.), yet there are limits to the extent that plants can expand at each site. Firstly, they are hemmed in by the forests and can only expand under a forest canopy when gaps occur. Weeds or pioneer species grow much faster than *D. palmeri* and hence are likely to outcompete it in most situations i.e. those with enough soil for seed germination and establishment. This was evident by the common occurrence of weeds at *D. palmeri* sites. At Mt Cordeaux in south-east Queensland, *Ageratina riparia* is spreading down one whole cliff-face and appears to be outcompeting *D. palmeri* (pers. obs.). Secondly, the vegetative expansion of the *D. palmeri* plants is limited by the size of the rock ledges on which they grow. The large mature *D. palmeri* plants would require an equally large ledge to support it and the new ramets. Thirdly, the clumps of *D. palmeri* plants that are growing in lithosols between the ledges cannot expand because the ledges are surrounding the plants. *Doryanthes palmeri* appears to only grow on the top of large ledges or to a limited extent between ledges. The presence of *D. palmeri* at any one site, therefore, does not imply that its population is

being adequately maintained, particularly at sites where flowering is rare. A lack of flowering means that the plant is also unable to reproduce vegetatively because no new ramets are stimulated into growth. The position and survival of *D. palmeri* at a site may be tenuous, especially when exposed to interspecific competition or disturbance.

Tree fall at *D. palmeri* sites has mixed results for the plants. It can provide the gap in the canopy needed for *D. palmeri* to flower in shady situations. Alternatively, it can dislodge *D. palmeri* from its position in the landscape and open up sites to weed invasion. For example, at Springbrook Plateau there was a population of *D. palmeri* growing on the top of and down a cliff-face. During a severe storm, a tree growing on the cliff-top fell over and down the cliff-face taking with it all the *D. palmeri* plants and all the soil in its path leaving only bare rock. Two to three years later, a few *D. palmeri* seedlings had begun to establish but were soon outcompeted by *Ageratina adenophora*. To date there are no *D. palmeri* seedlings evident on this cliff-face (M Hall pers. comm.). Drought can kill trees along cliff-tops (pers. obs.) and with decomposition their vulnerability to falling is increased.

Doryanthes palmeri is a protected plant under the NSW *National Parks and Wildlife Service (NPWS) Act 1974*. Harvesting of protected plants is managed by a licensing system administered by the NSW NPWS. This does not prevent illegal harvesting. No licences have been issued for *D. palmeri* (NPWS pers. comm.), yet it is available from plant nurseries in north-east NSW and is used for landscaping in the City of Lismore and in private homes (pers. obs.). Illegal harvesting of *D. palmeri* seeds is a potential threat to its populations. Seed is a precious resource for most rare species and 'normal' additions are required to maintain a population (Cropper 1993). This suggests that the number of *D. palmeri* plants at each site, and particularly the low numbers on the cliff-tops, are being maintained by the 'normal' seed supply. The removal of seeds may be detrimental to the genetic diversity and stability of the population and requires further investigation.

Herbivores may be a potential threat to seedling establishment and juvenile success. At Wanganui Gorge juvenile numbers were low. Those that were present had been grazed and trampled leading to the death of some plants. This may reduce the genetic variability, and hence the health of plants, within a population.

Many fires occurred in the National Park areas that contain *D. palmeri* (M. O'Connell pers. comm.⁵). Nine years ago, two fires burnt in the vicinity of the *Doryanthes palmeri* populations at Mt Warning and Sphinx Rock. These sites contain some of the largest populations of *D. palmeri*. This suggests that fire may play a role in the life cycle of *D. palmeri*, for example, by removing plant competition allowing *D. palmeri* seedlings to become established. Alternatively, the rocky ledges may provide *D. palmeri* with a refuge during fire events. *Doryanthes excelsa* has the ability to pull its underground stems further into the deep sandy soils during dry periods that precede fire, thus preventing damage to its regenerative parts (Rymer 1983). Seedlings and juveniles of *D. excelsa*, however, do not have this ability until they are at least 10 years old (Nash 1996). In contrast, *Doryanthes palmeri* does not have this ability at any stage due to the very shallow soils (i.e. less than 5 cm) overlaying the substrate (pers. obs.).

Conservation

Although most populations of *Doryanthes palmeri* are conserved in national parks, this does not necessarily afford adequate protection of the species. For example Cropper (1993) found that competition from weeds, illegal seed/plant harvesting, disturbance by visitors were threats to the survival of endangered plants in national parks. Doryanthaceae is one of only a handful of Australian endemic families, therefore, its conservation is important not only in Australia, but also worldwide.

The coding system specified by the International Union for the Conservation of Nature and Natural Resources (IUCN) for the IUCN Red List Categories (Mace and Stuart 1994) is used for the TSC Act. The IUCN criteria outlined here relates specifically to the NSW *D. palmeri* populations discussed in this paper. However, examples from the south-east Queensland sites are used as supporting evidence.

A taxon is Vulnerable when it is facing a high risk of extinction in the wild in the medium-term future. Some populations of *D. palmeri* may be reduced by at least 20% within three generations (i.e. 39 years), based on illegal seed harvesting and a decline in its area of occupancy and quality of habitat from the effects of introduced weeds. The area of occupancy is estimated to be less than 1 km² and is severely fragmented.

Doryanthes palmeri takes 13 years to mature and flower. It is then able to produce new rosettes which may then take a further 13 years to flower. In the meantime, the weed species at *D. palmeri* sites would have undergone many generations in 13 years and have expanded their populations. The example of weeds outcompeting *D. palmeri* at Springbrook Plateau and Mt Cordeaux is evidence that population sizes and potential sites of *D. palmeri* may be reduced by weed competition. Weed competition and illegal seed harvesting, particularly in conjunction with disturbance (e.g. tree fall), has the potential to reduce some populations of *D. palmeri* by at least 20% over the next 40 years due to shading and competition, and lack of new recruits into the population. The populations are severely fragmented from poor dispersal abilities and the area of occupancy will continue to decline due to the reduction of habitat quality. Indeed, populations under these conditions may become extinct at some sites.

The occurrence of fire in the *D. palmeri* populations remains a possible threat within the overall landscape and requires consideration, particularly escaped fires from fuel-reduction regimes by private landholders and State authorities. Further research on the effects of fire on *D. palmeri*, the genetic structure of different populations and its reproductive capabilities are high priorities for the management and conservation of this rare species.

The prolific occurrence of weeds, illegal seed harvesting and possibly fires appear to be placing the severely fragmented populations of *Doryanthes palmeri* under threat. The data from this study suggests strongly that *D. palmeri* should be included as a Schedule 2 (Vulnerable) species under the NSW *Threatened Species Conservation Act 1995*.

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